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The First Three Larval Stages and Feeding Behaviour of Phyllosoma of the New Zealand Palinurid Crayfish *Jasus edwardsii* (Hutton 1875)

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Abstract

Jasus edwardsii larvae, after a very brief naupliosoma phase, take about three weeks in southern New Zealand early summer conditions for the Stage I phyllosoma, then moulting to the Stage II phyllosoma. The naupliosoma has plumose swimming second antennae. Stage I phyllosomas have a body length of 2.1–2.2mm, and show only minute rudiments of the fourth pair of legs. Stage II phyllosomas have a body length of 2.7mm, and biramous 4th leg rudiments 0.3mm long. The phyllosomas showed no feeding response to an assortment of planktonic animals, but were found to feed voraciously on pieces of capitellid polychaet. The hypothesis is provisionally put forward that phyllosomas in this species may be largely benthic scavengers rather than planktonic in their habits.

INTRODUCTION

THIS study, of a preliminary nature, was stimulated by a remark made to me by Dr D. I. Williamson at the Port Erin Marine Biological Station. He commented that, just before he had returned from Australia, he had observed phyllosoma larvae of the Australian *Jasus* nibbling hydromedusae, and he thought these might be their natural food. An earlier attempt of mine to feed *Jasus edwardsii* phyllosomas had been unsuccessful, and it seems that palinurid larvae have in the past proved notoriously difficult to rear. For instance, Johnson (1956) states, of *Panulirus interruptus,* "the young hatched readily in aquaria, but attempts at rearing the larvae were futile. Other investigators have had similar experiences in attempts at rearing the phyllosoma larvae of other species." A recent exception to this is a study by Saisho (1962), who reared *Panulirus japonicus* phyllosomas through 10 ecdyses, using brine shrimp larvae as food.

Jasus edwardsii is by far the most important species economically in New Zealand's total fisheries. During the first decade after World War II, with the exploitation of stocks in the southern fiords, the New Zealand crayfishery rose steeply in value. From £29,100 in 1946 it ascended to £966,361 in 1956—a 33-fold increase. After dropping during the next three years, it then rose steadily,

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just to exceed £1 million in 1962, and to make £1,157,488 by 1964. It was by then worth nearly two-thirds the total received from all the vertebrate fishes (£1,899,772). Although this is its maximum recorded value to that date, the maximum weight of crayfish was fished in 1956. The figure for that year, of 130,815cwt, considerably exceeded the 1964 figure of 90,307cwt (N.Z. Marine Department Reports on Fisheries for the years 1946–1964). For a single species that plays such a major role in the country's total fisheries, a fuller knowledge of its life history and biology is clearly desirable.

As phyllosoma larvae are taken only occasionally in plankton (Johnson, 1956), making the indirect working out of the early life histories of palinurids extremely expensive in terms of research vessel time by this method alone, attempts to feed and rear *Jasus edwardsii* larvae in the laboratory seem indicated.

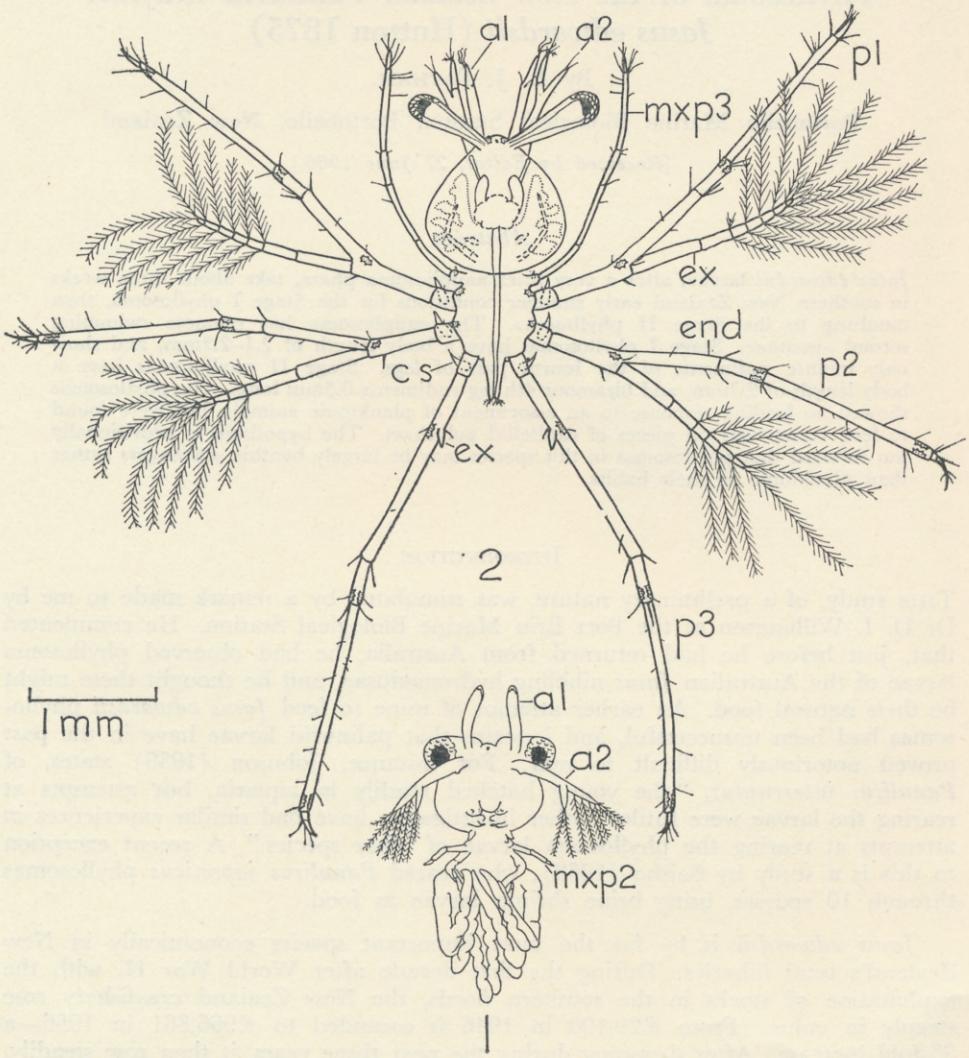


Fig. 1.—Naupliosoma larva, ventral view. Fig. 2.—Stage I phyllosoma larva, dorsal view, living specimen, to same scale as Fig. 1: a1, first antenna; a2, second antenna; mxp2, 3, second and third maxilliped; p 1, 2, 3, first, second and third legs (pereiopods); ex, exopodite; end, endopodite; cs, coxal spine.

Simple illustrations of the Stage I phyllosoma for this crayfish have been given by Thomson (Anderton, 1906), by Archey (naupliosoma and first phyllosoma), in 1916, and by Wear (1965). However, the recent observations by Holthuis (1963), indicating that the southern hemisphere genus *Jasus* is represented by different species in South Africa, Australia and New Zealand, point to a need for a more precise characterisation of the larvae of the New Zealand *J. edwardsii*. Hence the Stage I phyllosoma is re-figured and re-described. The Stage II phyllosoma of *J. edwardsii* has not, to my knowledge, previously been figured.

Methods

Drawings were made with the aid of a camera lucida of living larvae, and of parts either mounted in formalin, or stained with lignin pink in 70% cellosolve and mounted in Euparal.

Larvae were reared for up to four weeks in assorted glass containers. 23cm glass bowls were either aerated (with daily changes of bowl and filtered seawater) or had a slight flow of seawater through them, overflowing through a bolting silk rim. 10cm diameter glass cylinders with bolting silk tied over the lower end were placed on stands in battery jars of running seawater. Counted numbers (3 to 33) of larvae were placed in each container. Four reached Stage II phyllosoma in an aerated bowl, and one in a cylinder. Some contamination occurred with bacteria, protozoa and in some instances fungi, especially during warm weather late in November when casualties were heavy. These results suggest that, for further rearing, some form of filtering and sterilising of the seawater, together with a means of keeping it cool, is desirable. Although the larvae feed readily in captivity, the great length of the larval period will offer difficulties in rearing specimens through from newly hatched larvae to the puerulus stage.

Observations

Eggs and Hatching

A crayfish in the Portobello Aquarium was observed to be carrying eggs on 24 September 1965. Enclosed in the egg cases were half-developed embryos, about equal in size to their yolk sacs. These hatched six weeks later. The egg cases, each on a slender, twined stalk, were transparent, spherical and 0.70–0.75mm in diameter. The yolk was orange.

Weekly checks of eggs showed that by 5 November yolk was no longer observable. From then on the female crayfish was observed several times daily. On the afternoon of 7 November P. Sparks reported that she was raising her abdomen and moving her pleopods, but neither then nor at 11 p.m. that evening could he see larvae released. By 8 a.m. the following morning he found hundreds of larvae at, or swimming towards, the surface of the large aquarium tank. A sample of these which I examined at 11 a.m. proved all to be phyllosomas. The female, still carrying the majority of her embryos on her pleopods, was transferred to a small glass tank with running seawater in a laboratory and intermittently observed, but no further hatchings were seen that day. That night (8–9 November), a further large number of larvae hatched. During the day of 9 November, a few larvae were seen to be released, at the small, round, naupliosoma stage. Each of these, transferred to a glass bowl and observed under binoculars, moulted to a phyllosoma within an hour, and usually within a few minutes. During the night of 9–10 November, several hundred larvae were released during the evening, several hundred

more between 11 p.m. and 3 a.m., and a number more by 9 a.m. the next morning. The next day, the female's pleopods showed a mass of empty egg cases and a sprinkling of undeveloped eggs, but no further developed embryos were seen.

Hatching is thus seen to take place chiefly during the night hours, on three successive nights.

The female crayfish, a specimen from Otago waters, had been in the Portobello Aquarium for some time when observed to be carrying eggs, fertilisation having probably occurred in captivity. In late September, when her eggs were first noticed, female crayfishes checked in Otago Harbour were no longer carrying eggs. The female in the present study, on 10 November 1965, measured 26.0cm from the tip of her rostral spine to the end of her tail fan. Subsequent to carrying these eggs, she did not moult until 8 March 1966. One 10 June 1966, her length was 27.1cm.

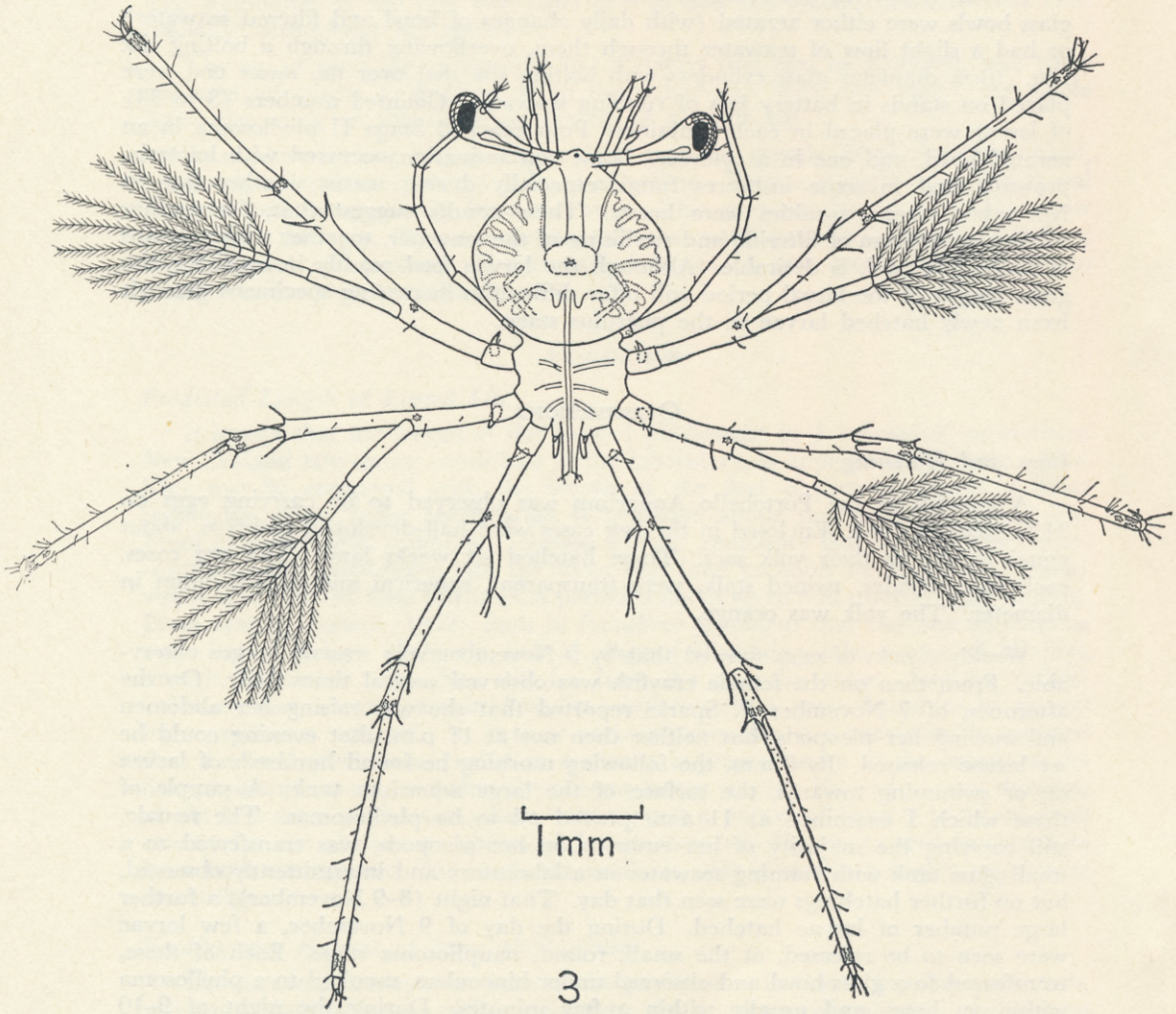


Fig. 3.—Stage II phyllosoma larva, dorsal view, living specimen, to same scale as Figs. 1 and 2.

Naupliosoma

Each larva removed as it was released from the pleopods of the female proved to be at the naupliosoma stage. This thus almost certainly is the newly-hatched form in *Jasus edwardsii.* However, as no late embryos in glass bowls hatched while I was actually watching them, I am not absolutely certain of the absence of a pre-naupliosoma stage, such as has been described by von Bonde (1936) in the South African crawfish, *Jasus lalandii,* although it seems highly improbable.

The naupliosoma is a rather round-shaped larva (Fig. 1), that swims slowly upwards with its rowing biramous second antennae. These, in the late embryo and in the naupliosoma, are setose and relatively large in relation to the thoracic limbs. They are the active large appendages in this briefly transient larval stage. The first three pairs of thoracic limbs at this stage are folded under ventrally, their endopodites condensed in tight zig-zags.

Judging from von Bonde's figure (Plate X, 1936), the *J. edwardsii* naupliosoma does not have such proportionately large antennae as that of *J. lalandii,* and is a larval phase of much briefer duration.

Moult from naupliosoma to first phyllosoma

This was observed several times, and takes only a few minutes. The first obvious external change is the elongation of the eyestalks. Then the cephalic shield expands laterally as the naupliosoma skin is being shed. The first and second antennae become inactive and hang down ventrally. The first, second and third pairs of thoracic limbs, whose endopodites were concertina'd within their coverings in the naupliosoma, now straighten and elongate with twitching movements. During this, the naupliosoma "skin" is being kicked off by the three pairs of thoracic limb endopodites, last resting on the tips of the large third maxillipeds. The plumose naupliosoma covering of the second antennae is not shed until slightly later than the main part of the "skin"; so that a very early Stage I phyllosoma may transiently appear to show plumose antennae. The larva lies on its back during this moult.

Stage I Phyllosoma

This is shown in dorsal view in Figure 2, while the appendages not clearly visible in this drawing are shown in Figures 6–8. The cephalic shield is rather flattened, broadly pear-shaped in outline, and wider than the hind-body (or thorax). In some fixed specimens its margins appear crenulate. The straight gut, lobed digestive gland and long, tubular heart are readily visible in living larvae. The small median and large compound eyes are black. The compound eyes show unsegmented stalks. On the anterior margin of each, a clear body (glandular?) is conspicuous. The abdomen is short and not obviously segmented. It terminates posteriorly in two slight protrusions, each of which carries a short, stout spine and three slightly longer, plumose setae (Fig. 4).

Body lengths, from the anterior end of the cephalic shield to the posterior end of the abdomen (excluding spines), were measured in 10 live phyllosomas seven days after hatching. They were 2.1, 2.2, 2.2, 2.2, 2.2, 2.1, 2.0, 2.2, 2.2 and 2.2mm, mean 2.16mm. Five live Stage I phyllosomas, measured 20 days after hatching, were 2.2, 2.2, 2.2, 2.1 and 2.1mm long, giving virtually the same mean. The Stage I phyllosoma overall measures 7.4mm across, and the width of the cephalic shield is 1.2mm.

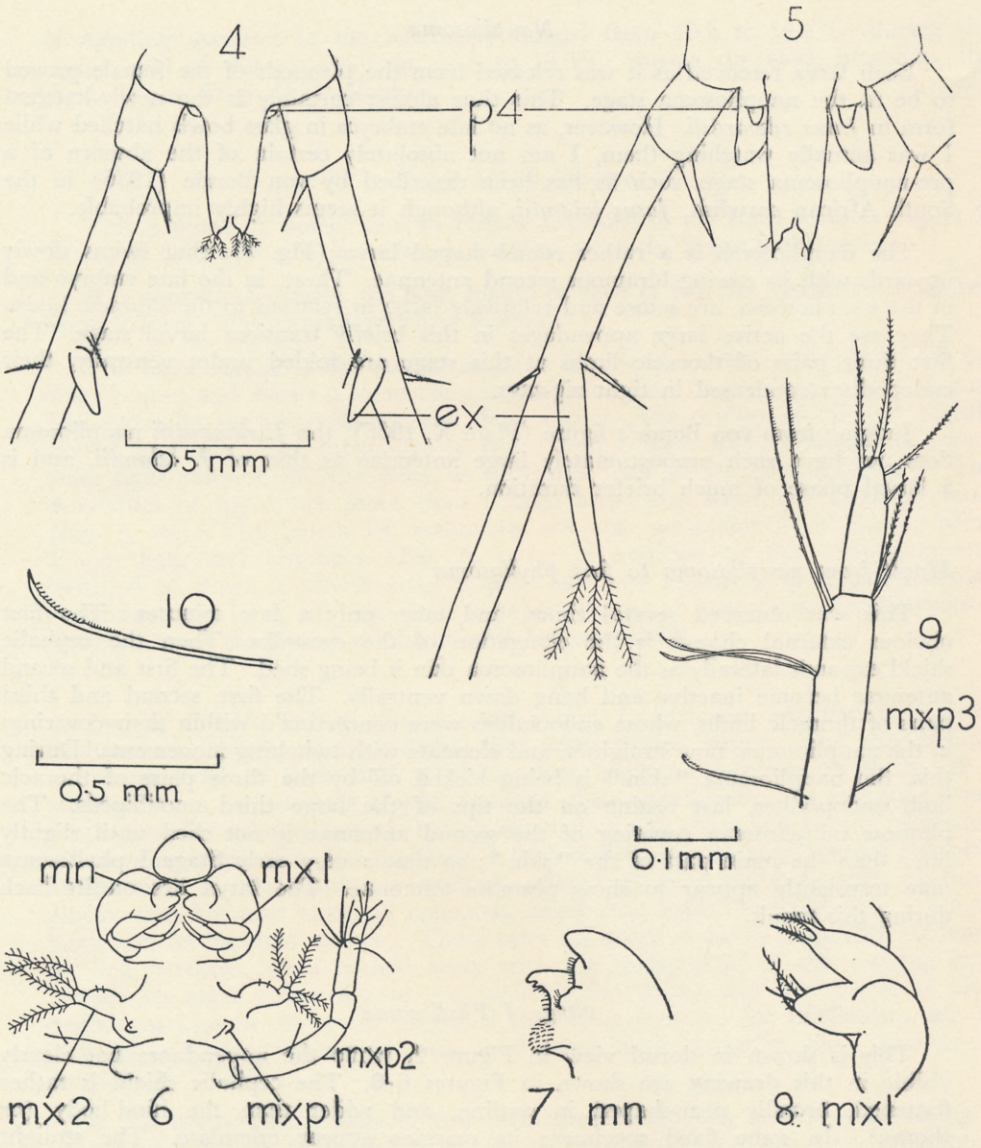
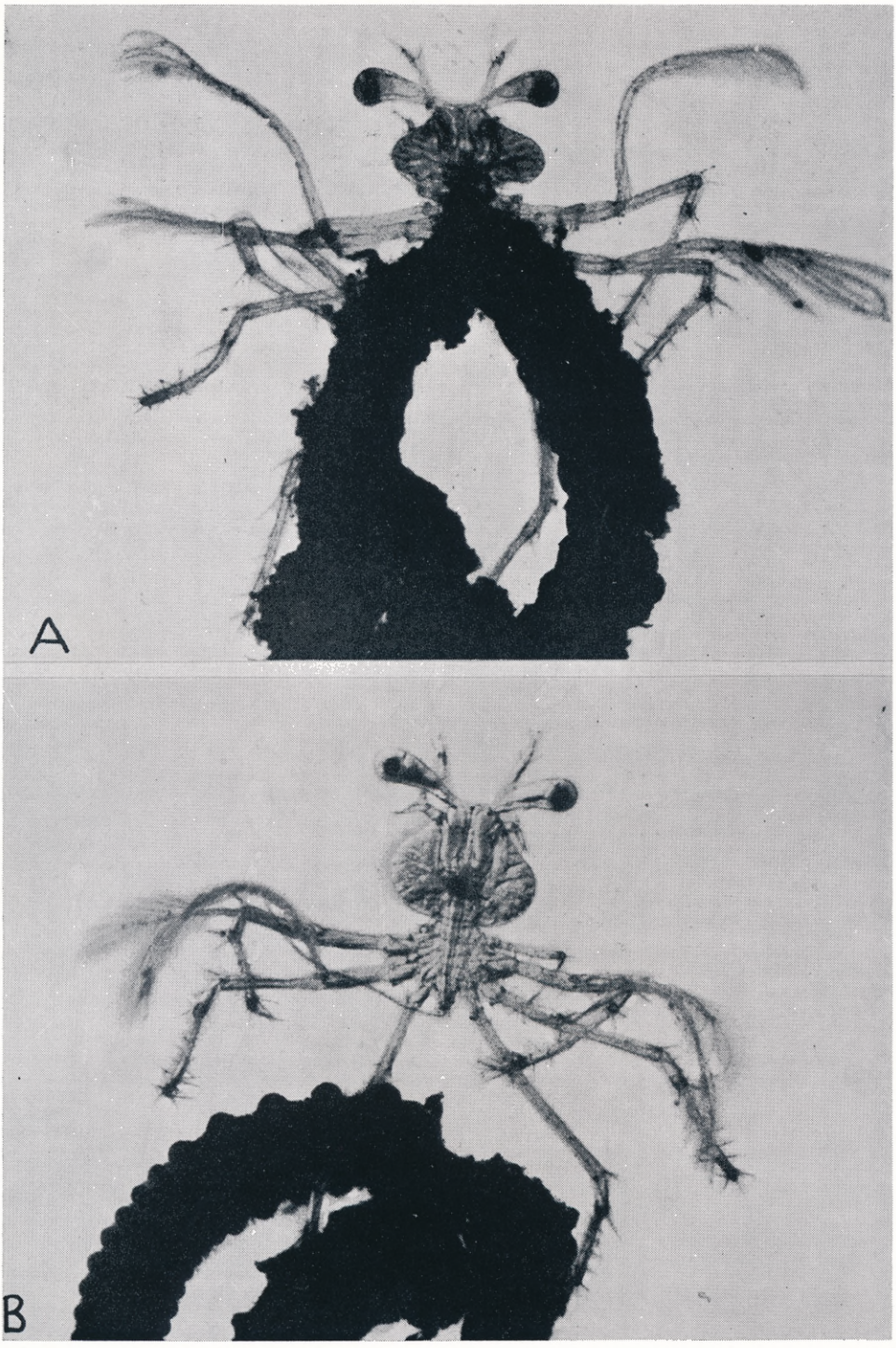


Fig. 4.—Stage I phyllosoma, posterior end, dorsal view. Fig. 5.—Stage II phyllosoma, posterior end, dorsal view, to same scale as Fig. 4. p4, fourth leg; ex, exopodite of third leg. Fig. 6.—Mouthparts and maxillipeds 1 and 2, ventral view, in situ. mn, mandible; mx1, first maxilla; mx2, second maxilla; mxp1, first maxilliped; mxp2, second maxilliped. Fig. 7.—Mandible. Fig. 8.—First maxilla. Fig. 9.—Top of left third maxilliped, viewed ventrally; 0.1mm scale applies to Figs. 7–9. Fig. 10.—Tip of inwardly-directed lateral seta of third maxilliped, highly magnified, showing pectinate end of cleaning organelle. Figs. 6–10 of Stage I phyllosoma.

The first antennae (antennules) are uniramous and unsegmented. Each at its tip has about three usually bent or damaged setae. One-third from the tip, two lateral setae arise. The second antennae are biramous, their two rami being of approximately equal length. The inner one faintly shows a joint, and carries apically one longer and two shorter setae, as well as a slender, plumose seta. The outer branch carries two stout, unequal setae apically.



Phyllosomas of *Jasus edwardsii* feeding on pieces of polychaet worm, photographed with electronic flash.

A. Larva, holding on with five of its six leg endopodites, pulls off piece of worm with its mouthparts.

B, After feeding, larva rises up off polychaet, holding on only with third leg endopodites. Note faecal strand passing towards left of photograph.

Labrum, mandibles and first maxillae (maxillules) are bunched together, forming a ventral protruberance beneath the centre of the cephalic shield. Each mandible (Fig. 7) shows a blade and a number of short, stout spines. The first maxillae (Fig. 8) are biramous. The anterior ramus terminates in two stout spines, the posterior in 2–4 bristles. The second maxillae are placed somewhat posterior to the rest of the trophi (Fig. 6). Each shows 1–2 lateral bristles, and terminates in four long, setose hairs.

The first maxillipeds are minute, usually unsegmented protruberances, each carrying 0–2 bristles (Fig. 6, mxp 1). This easily-overlooked pair of appendages lies immediately in front of the bases of the second maxillipeds. The second and third maxillipeds are slender, jointed appendages with relatively constant patterns of bristles (Figs. 6, 2, 9). The second maxillipeds are usually covered by the cephalic shield, but the third maxillipeds extend well beyond this. Both lack exopodites. Each third maxilliped shows a small, ventrally-directed coxal spine. The three or four inwardly-directed setae towards the extremity of each third maxilliped have curved tips, with a strongly pectinate inner margin (Figs. 9–10). These are presumably the effective organelles in the cleaning activities these appendages carry out.

The first and second pairs of legs (pereiopods) are conspicuously biramous (Fig. 2). Each endopodite terminates in a short, recurvable dactyl. Each of the exopodites of these legs in the Stage I phyllosoma carries sometimes five, more often six pairs of slender, plumose setae; each of these pairs arising from a point of articulation. The innermost setae are the shortest, ranging from nearly the length of the more distal setae down to a very short, sometimes unpaired seta. The third pair of legs shows slightly longer endopodites than the first two pairs, but their exopodites are only short flaps, either lacking setae or with rudimentary setae terminally. A stout coxal spine (Fig. 2, cs) is directed ventrally from each side of the first three pairs of legs, and usually has a short seta on its median side. At first glance, the fourth pair of legs appears absent in the Stage I phyllosoma. However, closer examination shows a minute pair of protruberances between the third leg bases and the abdomen (Fig. 4, p4).

Most of the setae and spines on the appendages are seen, under 16mm objective, to have tiny spines along their surfaces. Likewise the legs, parts of the maxillipeds and the antennae can be seen under this magnification to be irregularly sprinkled with tiny spines.

The chromatophores (Fig. 2) are reddish-orange. On the body, pairs occur at the sides of the median eye and at the bases of legs one and two. Each of the three pairs of legs shows a chromatophore at the level of bifurcation, and further ones on the endopodites, both halfway along the ramus and near its dactyl. When expanded, these endopodite chromatophores appear to be single; but on the rare occasions when their pigment is concentrated it is seen that two pigment spots lie close together.

The foregoing description and figures are based on phyllosomas from one Otago female. A few preserved phyllosomas from an earlier Otago hatching did not deviate detectably from this account. A single phyllosoma from plankton, from Hauraki Gulf, Auckland, was of the same size (2.1mm) and appearance. The only difference I could detect from the above description was the presence of an additional three small spines on each second antenna.

Duration of Stage I Phyllosoma

Five larvae were reared through to the second phyllosoma stage. These moulted respectively 19, 20½, 23, 24 and 25 days after hatching. Recorded day temperatures

of standing seawater in the laboratory ranged from 10.2 to 14.2°C. during the earlier part of this period, from 15.5 to 19.0°C. during the week preceding the moult to the Stage II phyllosoma.

Stage II Phyllosoma

This is shown in dorsal view in Figure 3, drawn to the same scale as Figure 2. It will be described only in so far as it differs from the Stage I phyllosoma.

It is appreciably larger, the body length of each of five live specimens measured being 2.7mm. The overall width is 9.5mm.

The inner ramus of the second antenna is now about twice the length of the outer ramus, and shows a more conspicuous joint than in the Stage I phyllosoma. The eye stalks are more slender, and show a joint. The compound eyes are slightly curved forwards. The exopodites of legs 1 and 2 show usually seven and sometimes eight pairs of plumose setae, as compared with (5–)6 pairs in Stage I. The exopodites of leg 3 are more than 0.5mm long, and show 2–4 terminal setae (Fig. 5, ex). The fourth leg rudiments are now noticeable at a glance, being 0.3mm long and biramous (Fig. 5, p4). In addition to the chromatophores recorded in Stage I phyllosomas, a pair has now appeared on the mouthpart protrusion, and in at any rate some instances there are now three chromatophores clustered near the dactyl of the second leg endopodite.

Testing Foods: I first offered some young *J. edwardsii* phyllosomas *Obelia* medusae, and some Anthomedusae that were rather larger. The phyllosomas swimming close to these and touching them gave no response to them. If I pipetted them on to their trophi, between their maxillipeds, the medusae were swept away by currents set up by leg exopodites. As there seemed no suggestion of a feeding response to the medusae, I then tested various other animals available at the time in the plankton. Animals offered at least twice to each of three phyllosomas included calanoid copepods, small crab zoeas, trochophores, a veliger larva and an ascidian tadpole. These were all swept away by exopodite currents, or, if I persisted, were pushed away with the endopodites of the walking legs. Unicellular algae cultures were not available for testing, but movements of incidental particles in the water suggested that what currents the phyllosoma set up with its exopodites carried possible food away from it, rather than towards its mouthparts.

A few hours later I noticed two phyllosomas clutching and possibly eating a very dead piece of polychaet that had come through the seawater circulation; recognisable only by its bristles. In case this had significance as food, I next presented to phyllosomas some pieces of a slender Capitellid polychaet, *Heteromastus filiformis* (Claparède, 1864), that is abundant in sand near the marine station. Phyllosomas tackled these pieces with apparent purposefulness, soon pulling portions off with their mouthparts. S. Austin tested phyllosomas on small pieces of muscle of the yellow-eyed mullet, and found they likewise ate these. I tested them on pieces of *Mytilus* muscle, but this was not eaten, perhaps being unsuited owing to its slimy surface or its firmer texture.

As Saisho (1962) had succeeded in rearing *Panulirus japonicus* through many of its phyllosoma stages on brine shrimp larvae, I offered some newly hatched brine shrimps to five *J. edwardsii* phyllosomas. The brine shrimp larvae swam freely amongst their legs and maxillipeds, but produced no reaction from the phyllosomas. I then offered these five phyllosomas a piece of Capitellid. Two

promptly grasped it and began feeding on it, indicating that lack of hunger was not the cause of ignoring the brine shrimps.

In view of these results, pieces of *Heteromastus* and other polychaets were subsequently used for feeding the larvae. Typically, in a bowl of 10 phyllosomas, one might be swimming at or near the surface, a couple swimming across the bottom, and the remaining seven would be clutching a piece of worm with their endopodites. Perhaps three of these last would show faeces emerging.

Feeding and Other Behaviour of Stage I Phyllosoma

The phyllosoma shows almost continuous beating of the exopodites of legs 1 and 2, as well as of the small second maxillae, though the latter can barely be seen unless they are dirty. While the larva is swimming freely in the water or along the bottom with its two pairs of feathery exopodites, the three pairs of endopodites are trailing—the first two pairs downwards, the third pair diagonally backwards. Throughout swimming, feeding and other activities, the antennules are held stiffly forward, the biramous antennae beneath them stiffly down, and no muscular activity of these organs was observed during this stage, although bundles of striated muscle fibres run to them. The two members of a pair of exopodites beat together and out of phase with the other pair. Frequency of exopodite beat was timed in a phyllosoma in sea water at 16.2° C. Four counts over 30 second periods gave 97, 94, 112 and 99, or a mean of 201 beats per minute. The beat may cease briefly, when a swimming larva drifts down in the water. In vitro, the larva spends part of its time slowly swimming in the water, more traversing along the bottom. During swimming it somersaults forwards not infrequently, and appears to have poor control of pitching. Sometimes its dorsal surface is uppermost, sometimes its ventral. The beating of the exopodites gives a flickering appearance to the whole larva, by which one soon learns to recognise a phyllosoma; for, although not minute, it is very transparent.

Feeding

When a broken piece of Capitellid polychaet is added to a finger bowl containing phyllosoma larvae, there is no obvious immediate response from the larvae, which continue swimming along the bottom or through the water apparently rather randomly. (Adult *J. edwardsii* in an aquarium tank, on the other hand, become obviously more active almost immediately when cut-up fish is added to their tank, as if distant chemo-reception is then important; and within a few minutes they have directly approached the cut fish and are eating it.) Presently, however, one or more larvae swim into the piece of worm.

A larva then grips the worm with some or all of its leg endopodites. The exopodites meantime continue their beating activity, now perhaps helping the larva to balance on the worm. The third maxillipeds are seen to touch the worm, and the larva is liable to move to a damaged portion (unless the whole piece of worm is soft and defunct). Soon it draws its body close to the broken worm surface and applies its trophi to this, holding on meantime with some or all of its leg endopodites. This position is maintained usually for some five to eight minutes. Then the body of the larva pulls away, and a portion of worm can be seen being pulled off by the larval trophi (Plate 1, Fig. A). Next, the larva raises itself from the worm, retaining contact with it with the last one or two pairs of endopodites only (Plate 1, Fig. B). The third maxillipeds now become very active, apparently carrying out cleaning movements over the trophi, the leg bases and sometimes

the antennules; modified, pectinate bristles being involved (Fig. 10). Once a third maxilliped was observed to reach the tip of the endopodite of a leg, but it appears as if they cannot reach the feathery exopodites, which tend to become rather dirty during the latter period of a larval stage. This intensive cleaning activity of the third maxillipeds, which work independently of one another, is continued for two or three minutes. Sometimes during this non-feeding phase a larva leans over backwards away from the worm, holding on only with the last one or two pairs of endopodites. At others, it omits this leaning, swaying activity, but stands with its body well clear above the worm. After this, the larva again comes closer to the worm, holding it usually with five or six leg endopodites at once. The third maxillipeds touch the worm as if feeling or testing it. Then the trophi are again applied, and the feeding cycle repeated.

One late Stage I phyllosoma was kept under observation for more than two hours. It fed in the above pattern for two hours ten minutes, stopped for about 20 minutes, and then resumed feeding. During the two hour ten minute period, this sequence of feeding activities was repeated 11 times with but slight variation. The exopodites of the first two pairs of legs and the second maxillae beat continuously throughout the period.

The tip of each leg endopodite has a dactyl that can be recurved, and these are used effectively in holding on to the polychaet. With one dactyl, the whole larva can swing on the worm on the tip of a single leg.

Soon after feeding begins the straight gut and greatly lobed digestive gland, previously colourless, appear a pale, clear yellow. Then a straight strand of faecal material emerges gradually from the anus. This presently becomes as long as or longer than the body. On one occasion, the third maxillipeds were observed handling the abdomen, and pushing off a thread of faeces. A new faecal thread began to emerge a few minutes later.

Discussion

Predicted Length of Larval Life

It is seen that the length of the Stage I phyllosoma in *J. edwardsii,* in southern New Zealand late spring conditions in the laboratory, is approximately three weeks. This can be compared with the length of the first phyllosoma stage in other palinurids where fuller information is available about the length of larval life. From extensive field sampling, Johnson (1960) concludes that in *Panulirus interruptus* the first phyllosoma lasts for about two (and probably not more than three) weeks, and that the total phyllosoma period is about seven and three-quarter months. From rearing, Saisho (1962) finds in *Panulirus japonicus* that the first phyllosoma stage lasts 7–8 days, whilst the first 11 stages (10 moults) take a total of 90 days, though the larvae were then still far from the puerulus stage. Johnson (1966) indicates that, at any rate in *Panulirus inflatus,* there were found to be several instars within a " stage ". If, in these various palinurids, it is provisionally assumed that the total phyllosoma period in a species is proportionate to the length of the first phyllosoma stage, and that the present larvae *in vitro* showed normal duration of the first stage phyllosoma, these data suggest a period of from 9 to 12 or more months for the phyllosoma phases of *Jasus edwardsii.* However, until further data from both rearing and field work are available, this is merely a highly provisional conclusion.

Feeding and Habitat of Jasus phyllosomas

The flattened, transparent form of the phyllosoma, in this as in other palinurids, suggests a planktonic way of life. However, the sparseness of palinurid phyllosomas in plankton has suggested to several workers (e.g., Johnson 1956, R. Pike, spoken

communication) that they might be at any rate partially benthic in their habits. The feeding behaviour of the *J. edwardsii* phyllosomas in the present laboratory study gives considerable support to this suggestion. Further, there is the comment by Gurney (1936), about *Jasus lalandii* off South Africa, " Most of the samples in which these Phyllosomas occurred were taken in deep water, but as the hauls were generally continued to the surface, they offer little evidence concerning vertical distribution ".

It may well be that habitat and feeding habits differ in the phyllosomas belonging to different genera and species of Palinuridae. Phyllosomas of both *Panulirus japonicus* (Saisho, 1962) and *Panulirus inflatus* (Johnson and Knight, 1966) have been found to feed on brine shrimp larvae. But brine shrimp larvae brought forth no feeding response from *Jasus edwardsii* phyllosomas, which on the other hand will clutch and eat pieces of polychaet and fish larger than themselves. The Australian *Jasus* larvae may behave somewhat comparably in eating medusae. *Jasus* phyllosomas are structurally noteworthy for lacking a feathery exopodite on their third maxillipeds, which is apparently regularly present in other palinurid phyllosomas (Gurney, 1936). Do these third maxilliped exopodites set up feeding currents that bring small planktonic organisms to the mouthparts of other palinurid phyllosomas? Is the absence of these associated with the grasping of larger food in *Jasus* larvae? Does such feeding behaviour in *J. edwardsii* phyllosomas turn them to being primarily benthic larvae? The present observations raise these points. It is hoped that extensive sampling at sea, both in the plankton and along the bottom, may answer the last question for the present species.

Acknowledgments

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Literature Cited

ANDERTON, T., 1906. Observations on New Zealand Fishes, etc., made at the Portobello Marine Fish-Hatchery. *Trans. Proc. N.Z. Inst.* 39: 477–496.

ARCHEY, G., 1915. Notes on the Marine Crayfish of New Zealand. *Trans. N.Z. Inst.* 48: 396–406.

GURNEY, R., 1936. Larvae of Decapod Crustacea. Part III. Phyllosoma. *Discovery Reports* XII: 400–440.

HOLTHUIS, L. B., 1963. Preliminary descriptions of some new species of Palinuridea. *Proc. K. ned. Akad. Wet.,* ser. C, 66, 1: 54–60.

JOHNSON, M. W., 1956. The larval development of the California spiny lobster, *Panulirus interruptus* (Randall), with notes on *Panulirus gracilis* Streets. *Proc. Calif. Acad. Sci.,* XXIX, 1: 1–19.

——— 1960. Production and distribution of larvae of the spiny lobster, *Panulirus interruptus* (Randall) with records on *P. gracilis* Streets. *Bull. Scripps Inst. Oceanog.,* 7, 6. 413–462.

JOHNSON, M. W. AND KNIGHT, M., 1966. The phyllosoma larvae of the spiny lobster *Panulirus inflatus* (Bouvier). *Crustaceana* 10, 1: 31–47.

MARINE DEPARTMENT. Report on Fisheries, Govt. Printer, Wellington, N.Z., 1946–1966.

SAISHO, T., 1962. Notes on the early development of phyllosoma of *Panulirus japonicus*. *Mem. Far. Fish. Kagoshima Univ.* 11, 1: 18–23.

VON BONDE, C., 1936. The Reproduction, Embryology and Metamorphosis of the Cape Crawfish (*Jasus lalandii*) (Milne Edwards) Ortmann. *Dept. Com. Ind. Fisheries and Mar. Biol. Survey Div., Invest. Rep.* No. 6.

WEAR, R. G., 1965. Zooplankton of Wellington Harbour, New Zealand. *Zool. Publ. Vict. Univ., Wellington,* No. 38.

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